GRAVITATION EFFECT ON A FLUX OF SPORADIC MICROMETEOROIDS IN THE VICINITY OF NEAR-EARTH ORBITS

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ABSTRACT

The new approach to gravitation effect determination in calculating the flux of sporadic micrometeoroids in the near-Earth space is proposed. The technique is based on integrating the equations of motion of sporadic micrometeoroids with allowance for bending their trajectories when particles approach the Earth. The technique and results of calculation of the gravitational focusing factor k_g for various conditions are presented.

The feature of the proposed technique for calculating coefficient k_g consists in the fact that this coefficient does not explicitly depend on the values of particles' velocity at the last point. The results of investigation of coefficient k_g have shown that for the given initial velocity of micrometeoroids the values of this coefficient depend on deflection of its trajectories from the direction to the Earth center. It is shown that for low-altitude orbits the flux density growth can reach 60 %. The distribution of probabilities of various directions of particles flying to spacecraft structural elements is found to be non-uniform.

1 INTRODUCTION

The influence of micrometeoroids on the space flight safety has drawn specialists' attention since the time of launching of first satellites. Even on the first re-entry spacecraft the plates made of various materials were installed — to estimate the degree of micrometeoroids influence. After long staying in orbit these test plates became such, as if they were ''eaten-through'' by microcraters. Investigations have shown these particles to have various sizes (from some microns up to 1000 mm) and various velocities reaching 72 km/s [1].The most informative measurements have been obtained on the American satellite LDEF (Long Duration Exposure Facility) [2,3]. It was launched into orbit in 1984and was staying in the near-Earth space (NES) for more than 5 years, after which it was returned to the Earth in1990 by the ''Shuttle'' Columbia. The uniqueness of this experiment consisted in the fact, that the satellite was stabilized, had large size (9.1_4.3 m), and its whole surface was some kind of a sensor of collisions. The surface of the LDEF satellite was carefully studied by many specialists. Some thousand craters were found, which were formed as a result of collisions with micrometeoroids and man-made space debris particles. Chemical analysis materials allowed one to separate these two types of collisions.

The American specialist B.G. Cour-Palais in 1969 has constructed the micrometeoroid flux model [4], which became a basis for further investigations and remains rather popular till now. The variety of micrometeoroid models has been developed in subsequent years [5–11].In 2009 the group of specialists prepared the survey report on comparing various models of micrometeoroids [12].Based on the results of investigations it was found that, unlike the flux of micrometeoroids, the flux of sporadic meteoroids was stationary. Besides, it was assumed that, relative to the Earth surface, the sporadic meteoroids arrive isotropically from all directions and with the same velocity. To correct for Earth's gravitational enhancement at the given distance above the Earth, the average meteoroid flux must be multiplied by the defocusing factor G_e [13].

With reference to paper [13] mentioned above, the MASTER model documentation [10] outlines the algorithm of calculating the defocusing factor which is designated now as χ (H). Here H is the altitude above the planetary surface.

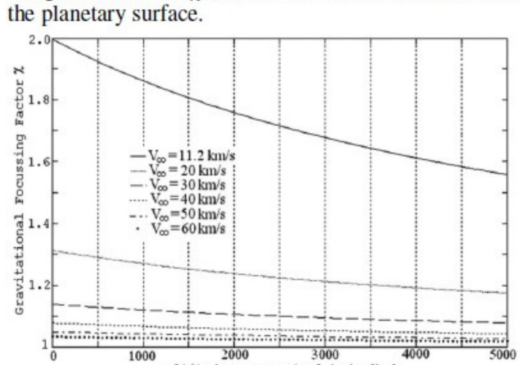

Figure 1. Gravitational focusing factor V_∞.

This algorithm is very simple:

$$\chi(H) = \left(\frac{V(H)}{V_\infty} \right)^2. \qquad (1)$$